*The*
# PSYCHOLOGICAL RECORD

Vol. I OCTOBER, 1937 No. 18

## BRIGHTNESS DISCRIMINATION FOR VARYING DURATIONS OF THE JUST DISCRIMINABLE INCREMENT

C. H. GRAHAM, R. H. BROWN, AND J. R. SMITH

*From the Psychological Laboratories of Brown University and Clark University*

**The Principia Press, Inc.**
**Bloomington, Ind.**

*Price of this number, 10 cents*

**EDITOR**

J. R. Kantor
*Indiana University*

**MANAGING EDITOR**

C. F. Scofield,
*Indiana University*

**DEPARTMENTAL EDITORS**

**Abnormal**
Edmund S. Conklin,
*Indiana*

**Child**
Helen Koch,
*Chicago*

**Clinical**
B. M. Castner,
*Yale*

**Comparative**
E. A. Culler,
*Illinois*

**Educational**
J. G. Peatman,
*C.C.N.Y.*

**Experimental**
B. F. Skinner,
*Minnesota*

**Medical**
Norman Cameron, M. D.,
*Johns Hopkins*

**Physiological**
C. M. Louttit
*Buffalo*

**Psychometrics**
J. P. Guilford,
*Nebraska*

**Social**
Norman C. Meier,
*Iowa*

**Editorial Assistant,** J. W. Carter Jr., *Indiana*

The Principia Press, Inc., has undertaken the publication of this co-operative journal to afford authors the opportunity of immediate publication at the least possible expense. The present low cost of publication, and possible future reductions, depend entirely upon the number of subscriptions. The subscription price has been made low to induce individuals to subscribe. Under the Articles of Incorporation of the Principia Press no profit can be made on any of its publications. Therefore an increase in the number of subscribers will be reflected in reduced costs to authors and an increase in the number of pages published annually.

EDITORIAL BOARD. The above named board of associate editors have agreed to serve in an active capacity for a period of three years, and all manuscripts will be submitted to them.

MANUSCRIPTS may be sent to the appropriate associate editor or to Dr. J. R. Kantor. Longer papers (30 or more typewritten pages) in the above mentioned fields are especially desired.

COSTS. The cost of publication will be $2.00 per page of approximately 500 words. For tabular matter or illustrations in excess of 10 per cent of the total length of the paper there will be an excess charge of 75 cents per page. An additional 50 cents will be charged for each paper for the cost of covers.

REPRINTS. One hundred copies of each paper will be supplied gratis. Additional copies may be purchased in any quantity at a rate which will be set when the author is informed of the cost of publication.

ROYALTIES. Fifty per cent of the net income from the sale of individual copies, or from copies sold as part of back volumes, will be credited as royalties to the author's account. Royalties cannot be paid on income from subscriptions current in the year of publication.

SUBSCRIPTIONS. The subscription price is $4.00 per year for an annual volume of approximately 500 pages. Individual papers will be sold at an advertised price, which will depend upon the size of the article. Foreign subscriptions will be $4.50.

CORRESPONDENCE concerning editorial matters should be addressed to Dr. J. R. Kantor, Indiana University. Business correspondence should be addressed to Dr. C. M. Louttit, Principia Press, Inc., Bloomington, Ind.

# BRIGHTNESS DISCRIMINATION FOR VARYING DURATIONS OF THE JUST DISCRIMINABLE INCREMENT

C. H. GRAHAM, R. H. BROWN, and J. R. SMITH[1]

*From the Psychological Laboratories of Brown University and Clark University*

Hecht has proposed a theory of visual intensity discrimination[2] in terms of the photochemical processes which take place at the initial moment when the eye, already adapted to a given intensity, is exposed to a just discriminably higher intensity. The theory states that in order for intensity discrimination to take place the initial rate of photochemical decomposition on the introduction of $\Delta I$ is constant. Since the theory places emphasis on the rôle of initial events, it would seem important to determine the effect of varying the duration of $\Delta I$. This would be particularly true for short flashes where initial events [e.g., a short burst of nerve impulses (Hartline)[3]] might be expected to occur in relatively uncomplicated form. This report, which is preliminary to more extensive research (Graham and Kemp)[4], presents data on intensity discrimination for three durations of $\Delta I$: 0.018 second, 0.25 second, and long-continued exposure.

Use was made of a modification of the apparatus described by Smith[5]. As described by him, the apparatus consists of an optical system, so constructed as to provide two separate beams of light from the same source and equipped to permit gross variations in the intensity of both beams and fine variations in the intensity of one beam. Light from a thousand-watt lamp, after passing through a quartz cooling cell and a convex lens, is divided by a system of four totally reflecting prisms into two beams. The two beams are centered by two pairs of matched convex lens on semicircular apertures in a metal screen. The semicircles are covered with opal glass on the inside and are separated by a metal fin which projects perpendicularly from the screen, thus restricting the illumination of

[1] Babies Hospital, New York City.

[2] Hecht, S. A theory of visual intensity discrimination. *J. Gen. Physiol.*, 1935, 18, 767-789.

[3] Hartline, H. K. Intensity and duration in the excitation of single photoreceptor units. *J. Cell. Compar. Physiol.*, 1934, 5, 229-247.

[4] Graham, C. H., & Kemp, E. H. (In preparation.)

[5] Smith, J. R. Spatial and binocular effects in human intensity discrimination. *J. Gen. Psychol.*, 1936, 14, 318-345.

each semicircle to its single beam. The metal screen is attached to a large wall-board screen by screws, in such a way that the two stimulus objects are centered on the latter and appear to the subject as two separate illuminated semicircles in a dark field. As seen from the subject's side of the screen, the semicircles have a radius of 20′ and are separated by a visual angle of 4′15″.

The apparatus so far described makes it possible to equate (within approximately the limits of accuracy described by Smith) the intensities on the two semicircles. For the presentation of $\Delta I$ in the form of a flash we employed a third beam of light. A mirror placed at one side of the light source reflects rays which pass through a holder for neutral tint filters, a condensing lens, and a Wratten neutral tint wedge with balancing wedge. The rays finally diverge from a focus to illuminate the opal glass patch situated on the subject's left. An Ilex photographic shutter or a synchronous-motor driven exposure device similar to that used by Graham and Granit[6] can be placed in the focal point of the beam for the regulation of duration. The Ilex shutter is used for the 0.018 ($\pm$0.002) second, and the synchronous motor device for the 0.25 second flash. For the long-continued exposure there is no device in the third beam.

The procedure for any particular day consisted in having the subject make an equation point at a fairly high intensity of the two patches with the third beam occluded. After this was done, determinations were made to determine the necessary increment, $\Delta I$. The wedge in the third beam was placed in such a position that a clearly visible flash of light was superimposed upon the left-hand semicircle, and then the experimenter determined the threshold by decreasing the intensity of the beam. This procedure was followed for the continuous ("infinite") exposure series, except for the difference that the wedge was continuously moved in the more dense dirction until the subject reported "equal". Thresholds were determined for at least eleven values of prevailing intensity, $I$, at each of the three durations of exposure. R.H.B. served as subject.

The test of the applicability of Hecht's hypothesis to the data of this experiment centers on the question of how well the equation which he has developed for long durations of illumination describes our results. According to Hecht's hypothesis, the ratio $\frac{\Delta I}{I}$ should be related to intensity, $I$, according to the equation

[6] Graham, C. H., & Granit, R. Comparative studies in the peripheral and central retina. VI. *Amer. J. Physiol.*, 1931, 98, 664-673.

$$\frac{\Delta I}{I} = \frac{c}{a^2 k_2}\left(1 + \frac{1}{(KI)^{\frac{1}{2}}}\right)^2 \qquad (1)$$

where $\frac{c}{a^2 k_2}$ and $K$ are constants. Smith has formulated a convenient

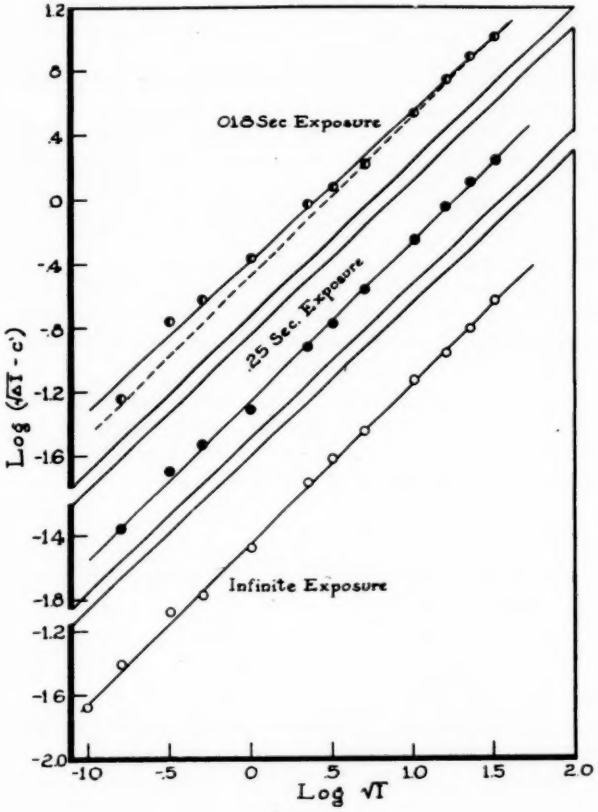


FIGURE 1

Theoretical plot of the data of this experiment. Explanation in text. The dashed line of the uppermost curve has a slope of unity; the solid line has a slope of 0.93. The two lower curves are drawn with a slope of unity.

test of this relationship in which log $(\sqrt{\Delta I - C'})$ may be plotted against log $\sqrt{I}$. The constant, $C'$ of this plot is equal to $\frac{C}{\sqrt{K}}$ where $C = \sqrt{\frac{c}{a^2 k_2}}$. It is this latter constant, $C$, which determines the position of the log $\frac{\Delta I}{I}$ vs. log $I$ curve on the ordinate. According to Smith's manner of plotting, our data should fall on a straight line having a slope of unity if Hecht's theory is applicable. Figure 1 gives a graph of the results obtained when the data are plotted in this manner. It is clear that the results fit the theoretical expectation fairly well, with the possible exception of the graph for the exposure of 0.018 second. However, the deviation in this case is not significant. It would be possible to get a somewhat better fit in terms of which all points except the lowermost would fit the line, the lowermost falling off more considerably as the fit for the others becomes better. Since this is so, we may say that, to a good approximation, the data for all of the durations of flash may be described by Hecht's hypthesis.

Our major interest concerns the behavior of the constants $C$ and $K$ for the three conditions of exposure. Table 1 gives the values of these constants for the three exposures, and it is to be observed that the constants vary for the various conditions.

TABLE 1

Values of $C$ and $K$ for Different Durations of $\Delta I$

| Duration of $\Delta I$ (sec.) | $C$ | $K$ |
|---|---|---|
| 0.018 | 0.350 | 5.4 |
| 0.25 | 0.274 | 25.0 |
| "Infinite" | 0.221 | 32.0 |

The asymptote determining constant of equation (1), $C$, is higher for the 0.018 second curve, than for the 0.25 second curve, and, in turn, the latter's $C$ is higher than the one for the infinite exposure curve. In addition, it is to be noticed that the constant, $K$, which determines the position of the curves of equation (1) on the abscissa is different for the 0.018 second curve from what it is for the other two curves. In general, it would seem that variation in the duration of flash determines the position of the curve on both the ordinate

and abscissa axes. This is what might be expected if intensity and time were interchangeable factors in the production of the photochemical effect due to the added increment $\Delta I$, and we should look for some such formulation as that involved in the Bunsen-Roscoe law to account for the difference in position of the curves. In addition, there will enter complications due to a critical duration beyond which time has no influence in the production of the photochemical effect and where intensity alone is the important variable. In order fully to determine the relation of the Bunsen-Roscoe law to the data of intensity discrimination for flashes, it will be necessary to determine the influence of flashes of differing duration over a great range of durations.

A final point of interest lies in the fact that the C values differ for the 0.25 second and infinite exposure curve. Some variable other than intensity alone must account for this. The most obvious influence is the rate of change in the application of intensity under the infinite exposure conditions.

*Summary*: Hecht's equation for brightness discrimination adequately accounts for results obtained with a constant duration of $\Delta I$. When the duration of $\Delta I$ is varied, the constants of the equation assume different values.